PATENT SPECIFICATION

DRAWINGS ATTACHED

1,052,513

Date of Application and filing Complete Specification: Feb. 24, 1964.

No. 7597/64.

Application made in United States of America (No. 290,816) on June 26. 1963.

Complete Specification Published: Dec. 21, 1966.

© Crown Copyright 1966.

1,052,513

Index at acceptance:—H1 D(5A, 5C2, 5Q, 9D, 9H, 9Y, 11X, 11Y, 12B4, 12B6, 12B47Y, 35, 38)

Int. Cl.:—H 01 j 7/26

COMPLETE SPECIFICATION

Flash Device

We, EDGERTON, GERMESHAUSEN & GRIER, INC., a corporation organized under the laws of the State of Massachusetts, United States of America, of 160 Brookline Avenue, Boston 15, Massachusetts, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates generally to electric arc-discharge flash devices and more particularly to those which are fluid-cooled.

In electric arc-discharge flash devices the flash is produced by an electrical discharge across a gap between a pair of electrodes and is characterized by being of a high-density and short duration. The medium between the electrodes may be air, an ionizable gas, such as xenon, or argon, or it may be a high vacuum. In general, flash devices perform two major functions. In electronic flash tubes, the arc discharge is used as a light source, while in spark gaps, the arc discharge performs a switching operation but since the devices used in these different applications, differ merely in the function they serve, some flash devices are used interchangeably as light sources and switching devices.

In these devices heat is generated by the discharge and this has long been a problem in their design, construction and operation. The dissipation of this heat is more serious the higher the flash repetition rate and the higher the power level employed and the need for efficient disspiation of this heat has been an important limitation upon the maximum power of the discharge and the maximum flash repetition rate at which the flash device can be operated, as well as upon the minimum physical size of the flash device which can be employed. Generation of heat in excess of the heat-dissipating capabilities of the device has led to severe damage of and even destroyed flash devices. The walls of the device, particularly in the case of light permeable envelopes such as glass or quartz, are subject to cracking and breaking. Seals are particularly vulnerable to excessive heat, and the electrodes may be ruined by such heat. These deleterious effects of excessive heat upon the envelope, seals, and electrodes of flash devices considerably shorten the life of the device and can be avoided only if the power discharged through the device and the flash repetition rate are held beneath certain maximum values. It is, therefore, apparent that the need to dissipate heat generated gives rise in itself to a serious limitation on the power and the repetition rate that can be employed and that because of this, the provision of a more efficient means of dissipating the heat will prolong the life of a device and make it possible at higher power and with a higher repetition rate.

The prior art techniques for cooling the device to dissipate heat range from blowing cool air past the device to emersing the whole device in a large container full of a cooling liquid, and suffer from one or more disadvantages. Many of the prior art methods required bulky apparatus. Others required very complicated apparatus and intricate means for effecting the cooling. Still others employed a pumping system for circulating a cooling liquid and required a coolant of special properties viz:— one having strong dielectric properties, such as carbon tetrochloride, mineral oil and demineralized water, to prevent any possibility of a short circuit to the cooling liquid from the high potential electrode to the low potential electrode. Further, the prior-art techniques concentrated their cooling efforts on certain parts of the device and neglected other parts, particularly the end portions and the seals.

It is, therefore, an object of the present invention to provide a simple, fluid-cooled flash device.

It is also an object of the present invention

to provide a flash device which may be cooled by tap water.

The present invention provides an electric arc-discharge device comprising a body having a passage therethrough constituting the electrode chamber of the device, and being formed to constitute a vessel for circulating coolant around the passage; the vessel being such that when filled with coolant, the coolant therein surrounds the passage over substantially its entire length.

The present invention will now be described, by way of example only, with reference to the accompanying drawings in which:—

FIGURE 1 is a parallel perspective view of a section of a preferred embodiment of the present invention;

FIGURE 2 is a like view of a second embodiment of the present invention;

FIGURE 3 is a like view of a third embodiment of the present invention; and

FIGURE 4 is a parallel perspective view partially in section of a fourth embodiment of the present invention.

Referring first to FIGURE 1, a pair of cylinders 5 and 6 are shown with cylinder 6, the smaller of the two cylinders, disposed substantially concentric with cylinder 5. The cylinders 5 and 6 may be of any suitable insulating material, for example, glass or quartz, either of which is very useful in flash devices used as light sources. The ends of the cylinders 5 and 6 are sealed to each other by any well-known sealing method. By completely sealing the ends of cylinders 5 and 6 a coolant chamber 12 constituting the above mentioned vessel is formed therebetween. The chamber 12 is itself of cylindrical configuration and is used to hold a flowing fluid. Chamber 12 is connected to a source of a flowing fluid by inlet 4 while outlet 8 provides egress for the fluid. Inlet 4 and outlet 8 are attached to the outer surface of cylinder 5 by any well known method and are disposed spaced from each other to provide maximum circulation and cooling of the device by the fluid that passes into chamber 12 by way of inlet 4 and out of chamber 12 by outlet 8.

Cylinder 6, the inner wall of chamber 12, defines a hollow centre portion in which electrodes 7 and 11 are disposed. Electrodes 7 and 11 are connected to an external source of potential by connectors 2 and 10 respectively. Electrodes 7 and 11 may be of any hard refractory conductor such as tungsten, but it is preferred that at least one of the principal electrodes 7 or 11 be a sintered electrode fashioned in the manner disclosed in U.S. Patent No. 2,492,142. Connectors 2 and 10 may be of any conducting material but preferably are copper tubing to which electrodes 7 and 11 are permanently attached. The use of copper tubing will be more fully explained hereafter.

In order to seal the interior of cylinder 6 thereby forming discharge chamber 13 for flash device 1, end caps 3 and 9 are employed to permanently connect the surface of cylinder 5 to connectors 2 and 10 respectively. End caps 3 and 9 are preferably of a metallic material which may readily be bonded to connectors 2 and 10 respectively by brazing, welding or the like. End caps 3 and 9 are bonded to the outer surface of cylinder 5 by well known glass-metal seals or by solder seals as disclosed in U.S. Patent No. 2,756,361. The discharge chamber 13 may be evacuated and filled with an ionizable gaseous medium such as xenon or argon by means of the hollow copper tubing connectors 2 and 10 as described in the U.S. Patent No. 2,756,361. The flash device 1 may be flashed by applying across electrodes 7 and 11 a potential which is greater than the impedance therebetween, thereby causing an arc discharge from one of the principal electrodes through the ionizing medium to the second of the principal electrodes. It is even more common to activate flash devices by means of a trigger electrode such as wire 14 shown disposed coiled about the outer surface of the flash device 1. By applying a trigger voltage to trigger electrode 14, the gaseous medium in the discharge chamber 13 is ionized thereby reducing the impedance between principal electrodes 7 and 11 and causing a discharge to take place therebetween.

It will be noted that the entire flash device is cooled through the circulating fluid that passes through inlet 4 into coolant chamber 12 and out through outlet 8. This cooling fluid completely fills coolant chamber 12 which is in the region of the discharge chamber 13 adjacent to the principal electrodes 7 and 11, and also passes in the region of the metal-to-glass seal in the region of the end caps 3 and 9. By effectively cooling all regions of the flash device, greater power may be discharged between principal electrodes 7 and 11 through the discharge chamber 13 and greater power levels may be discharged more rapidly, because the heat generated thereby will be readily dissipated through the flow of the cooling fluid. It should also be noted that end caps 3 and 9 overlap cylinder 5 for a substantial distance. This is done so that the heat transferred from connectors 2 and 10 through end caps 3 and 9 to the heat sink represented by the fluid in chamber 12 will not overheat the seals that bond the end caps 3 and 9 to cylinder 5, but rather the heat will be spread out over this substantial distance of the end cap and thereby be maintained at a relatively low temperature. It should be further noted that inlet 4 may be connected to a source of tap water so that ordinary inexpensive household water will flow through inlet 4 and fill coolant chamber 12 and then, while still under pressure, flow out through outlet 8. By using tap water, the need for circulating pumps which are expensive, is obviated. It is an important feature of the present invention that the coolant fluid does

not come into contact with any electrical connector at any point whatsoever in the flash device 1 and thus enables tap water to be used. The coolant is permitted to pass, as pointed out above, to the region of end caps 3 and 9 and also adjacent the discharge chamber 13 and the principal electrodes 7 and 11, but at all times the coolant fluid is separated from all electrical connectors by the wall of an insulator. However, other cooling liquids or fluids or gases may be employed, using a circulating pump.

In constructing the flash device 1 shown in FIGURE 1, a vitreous cylinder 6 of quartz or glass may be employed. In one example, a quartz cylinder 6 approximately 240 mm. in length with a 7-mm. inside diameter and a 9-mm. outside diameter was used. Cylinder 5 was of the same material as cylinder 6 and substantially the same length, and had an inside diameter of 13 mm. and an outside diameter of 15 mm. It is preferred for purposes of good circulation that at least a 2-mm. clearance be maintained between the walls of cylinders 5 and 6. Similarly, the diameter of inlet 4 and outlet 8 should be no less than 2 mm. The copper tubing suggested for connectors 2 and 10 may be quarter inch diameter and 0.60 inch thick, and of any length to accomplish its purposes. End caps 3 and 9 are of Invar although other metals such as Monel, Kovar and the like may be used. The words " Invar," " Monel " and " Kovar " are registered Trade Marks.

The flash device 21 shown in FIGURE 2 differs from the preferred embodiment of FIGURE 1 in that internal end caps 22 and 23 are used and inlet 33 and outlet 34 are disposed closer to the ends of the coolant chamber 29. A pair of members substantially cylindrical in shape 24 and 30 are joined together at their ends to form a coolant chamber 29 which is itself in the shape of a cylinder. The hollow interior centre of the coolant chamber 29 is employed to hold principal electrodes 25 and 26. These electrodes are maintained in position by end caps 22 and 23 respectively. Metallic connectors 28 and 27 are bonded to end caps 22 and 23 respectively by any of the well known metal-forming methods, such as welding, brazing, or soldering. A substantial portion of end caps 22 and 23 are bonded to a similar section of the outside wall of the coolant chamber 29 by glass-metal sealing methods or by the aforementioned solder sealing method. The heat generated at the principal electrodes 25 and 26 pass along connectors 28 and 27 respectively to end seals 22 and 23 whence it flows through the bonds between seals 22 and 23 and the wall of member 24 to coolant chamber 29 and the flowing fluid therein. The flowing fluid, whether it be tap water, a dielectric liquid, or a gaseous fluid, carries away heat from the seal, from the discharge region 32 and from the areas of the principal electrodes 25 and 26. Members 24 and 30 may be light permeable material such as the vitreous materials, for example quartz and glass, or it may be any other insulating material which does not pass light if the flash device is to be employed as a spark gap or as an electronic switch.

Flash device 41 of Figure 3 is made up of a pair of substantially cylindrical members 40 and 44. The ends of each of these members are sealed to themselves rather than to each other as was the case in flash devices 1 and 21 shown in FIGURES 1 and 2 respectively. Connectors 43 and 42 are used to connect electrodes 51 and 52 respectively across a source of high voltage potential. The portion of each of connectors 42 and 43 lying between members 40 and 44 is coated with a thin layer of insulating transition glass as shown at 46 and 50. Outer cylinder 44 and inner cylinder 40 are sealed to the transition glass coated on the connectors 42 and 43 to form a vessel 45 constituting a coolant chamber. The coating of transition glass along the connectors 42 and 43 intermediate inner and outer cylinders 40 and 44 insulates the metallic conductors 42 and 43 from the cooling fluid that passes through the coolant chamber of vessel 45 and provides a means of sealing cylinders 40 and 44 to metallic connectors 42 and 43. By this configuration tap water may be used and allowed to flow very closely to the connectors 42 and 43 without the danger of a short circuit because metal electrical connectors in all cases are insulated from the cooling fluid by either a wall of the cylinders 40 or 44, or the layers of insulating transition glass 46 and 50.

In this embodiment as in the embodiment of FIGURES 1 and 2, there is a coolant chamber of vessel 45 which surrounds the discharge chamber 47, the latter being part of the passage through the former. Means are provided for placing a pair of principal electrodes 51 and 52 within the discharge chamber 47 and for passing the connectors 42 and 43 from electrodes 52 and 51 respectively through coolant chamber of vessel 45 to a source of potential external of the flash device 41. The circulating fluid, be it water or a dielectric liquid, or a gas, flows into the coolant chamber through inlet 48 and circulates about the connectors 42 and 43, the discharge region 47 and about electrodes 52 and 51, and flows out through outlet 49.

In the embodiment shown in FIGURE 4 a helical shaped flash device 71 is shown. in this embodiment, a pair of helical members 73 and 74 are wound concentrically spaced from one another. Helical members 73 and 74 are joined together at their ends to form a coolant chamber 72 in the same manner that the ends of outer cylinder 5 and inner cylinder 6 are joined in FIGURE 1. Principal electrodes 81 and 82 are disposed in the discharge chamber 83 and maintained in their position

by connectors 77 and 80 respectively, which in turn pass through end caps 75 and 76 respectively. End caps 75 and 76 are bonded to connectors 77 and 80 respectively by any of the well known metal bonding methods such as welding and brazing. End caps 75 and 76 are bonded to the outer surface of helical member 73 by either the metal-glass sealing method or the solder sealing method. To maintain the seal at a relatively cool temperature, a substantial portion of the end cap is bonded to the member 73. A coolant fluid is circulated through coolant chamber 72 by way of inlet 78 and outlet 79 much the same as the coolant is circulated through the flash device of FIGURE 1. As was true of the embodiment previously discussed, the flash device of FIGURE 4 has a coolant chamber 72 which extends the full length of the discharge chamber 73 and passes in the vicinity of the seals of end caps 75 and 76, so that the entire flash device and its principal regions for producing heat are adequately cooled by the circulating coolant.

It will be clear that there are many other configurations in which the device of the present invention may be used, such as single loops and U-shapes.

It should be noted that the coolant employed in the embodiments disclosed need not be a clear coolant. In fact, there are advantages to adding dyes to the coolant in order to control the wavelength of the light output that passes from the arc discharge through the coolant chamber to the exterior thereof. In applications where it is desired to use a particular wavelength of light, it is a very simple matter to incorporate a particular dye in the coolant that will control the wavelength of the light output.

Although the present invention has been described in terms of flash devices having the primary functions of a source of light and a switching operation, our invention is also useful where a particular fluid is to be heat-treated or light-treated. For example, to pasturize a given fluid, it would be necessary only to cause said fluid to flow through the coolant chamber and flash the flash device with sufficient energy at regular repetition rates that the temperature of the fluid would be raised to a flash pasturization temperature. Similarly, there are applications where it is desired to subject a particular chemical substance, be it liquid or gaseous, to a flash of light to either effect a particular chemical reaction or to act as a catalyst in a chemical reaction.

As an example of the added efficiency obtainable from a flash device employing the cooling effect of the coolant chamber, a flash tube of the type shown in FIGURE 1 without using coolant in chamber 12 was found on operating with a 60-watt input level at 2,000 joules per flash, to be capable of being flashed safely once every 35 seconds. With a coolant (water at 70° F.), the same flashtube could handle 8,000 watts input, 2,000 joules per flash and be safely flashed four times a second. Furthermore, the same tube with no cooling was capable of a life of three minutes when it was flashed at 15 flashes per second, 200 joules per flash. By using the coolant, the same tube flashed 15 flashes per second at 200 joules per flash at a life of well over 10 hours. The tremendous increases in power, flashing rate and life, as evidenced by the above example, unquestionably demonstrate the superiority of this fluid-cooled flash device.

Although only the flash device disclosed in FIGURE 1 is shown having a trigger electrode, any and all of the embodiments of this invention may be activated by a trigger electrode in the form of a wire wrapped a turn or two about the outer wall of the flash device. The fact that a trigger electrode is separated from the discharge chamber by the coolant jacket has no effect in limiting the trigger action of the trigger electrode. The electric field produced by the trigger electrode passes through the coolant chamber to ionize the gas in the discharge chamber causing the discharge between the principal electrodes. It should, of course, be noted that the number of turns on the trigger electrode should not be sufficiently great to impair the light output when the flash device is employed as a source of illumination.

Further, it may be pointed out that the passage formed in the vessel may be disposed on any axis of the vessel.

WHAT WE CLAIM IS:—

1. An electric arc-discharge device comprising a body having a passage therethrough constituting the electrode chamber of the device, and being formed to constitute a vessel for circulating coolant around the passage; the vessel being such that when filled with coolant, the coolant therein surrounds the passage over substantially its entire length.

2. A device according to claim 1 wherein the vessel is formed of a light permeable material.

3. A device according to claim 1 or claim 2 wherein the electrodes for the arc discharge enter the passage one from each end thereof and are held in place by respective end seals through which the electrodes leads pass and to which the electrodes leads are sealed.

4. A device according to claim 3 wherein the seals take the form of caps sealed to an exterior face of the body other than that defining the passage.

5. A device according to claim 3 wherein the seals take the form of caps and the caps and the end portions of the passage are shaped so that the caps seat within the end portions of the passage.

6. A device according to claim 3 wherein the end seals take the form of sleeves and the body is formed so that the sleeves are part of the body and constitute end portions of the

passage; the electrode leads respectively being sealed to the sleeves internally thereof.

7. A device according to any of the preceding claims wherein the passage follows the course of a helix at least over part of its length.

8. A device according to any of the preceding claims wherein the body is formed of an electrical insulating material.

9. A device according to any of the preceding claims wherein the electrode chamber is gas-filled.

10. A device according to claim 9 wherein a trigger electrode is provided.

11. A device according to claim 10 wherein the trigger electrode lies outside the electrode chamber.

12. A device according to any of the preceding claims 1 to 8 wherein the electrode chamber is under high vacuum.

13. A device according to any of the preceding claims wherein the body is formed of two cylindrical sections joined together.

14. A device according to any of the preceding claims wherein the leads of the electrodes of the electrode chamber consist of copper tubes.

15. The electric arc discharge flash device substantially as hereinbefore particularly described with reference to any of Figures 1 to 4 of the accompanying drawing.

16. A method of producing light flashes by electric arc discharge which comprises passing an electric discharge between the electrodes of a device according to any of the preceding claims 1 to 15 and removing heat thereby generated by passing coolant through said vessel.

17. A method according to claim 16 wherein the device employed provides a vessel of electrically insulating material and prevents contact between coolant and the electrode leads.

18. A method according to claim 17 wherein the coolant employed is water.

19. A method according to claim 18 wherein the water is taken from a mains supply.

20. A method according to any of the preceding claims 15 to 19 wherein the coolant is coloured.

21. A process of heat-treating a fluid which comprises heating it to the temperature to which the fluid is to be submitted by passing it through a vessel of a device according to any of the preceding claims 1 to 15 undergoing flash discharge.

22. A process according to claim 21 wherein the fluid is heated by use as a coolant in the method according to claim 16 or claim 17.

23. A process according to claim 21 or claim 22 wherein the fluid is to be pasturised and said temperature to which the fluid is to be heated is the pasturization temperature.

24. The method of producing light flashes using a device according to claim 1 substantially as hereinbefore described.

25. The method of producing light flashes substantially as hereinbefore described with reference to any of Figures 1 to 4 of the accompanying drawing.

CLEVELAND AND JOHNSON,
Agents for the Applicants,
Chartered Patent Agents,
302—306 Bank Chambers,
329 High Holborn,
London, W.C.1.

Leamington Spa: Printed for Her Majesty's Stationery Office, by the Courier Press (Leamington) Ltd.—1966. Published by The Patent Office, 25 Southampton Buildings, London, W.C.2, from which copies may be obtained.

1052513 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

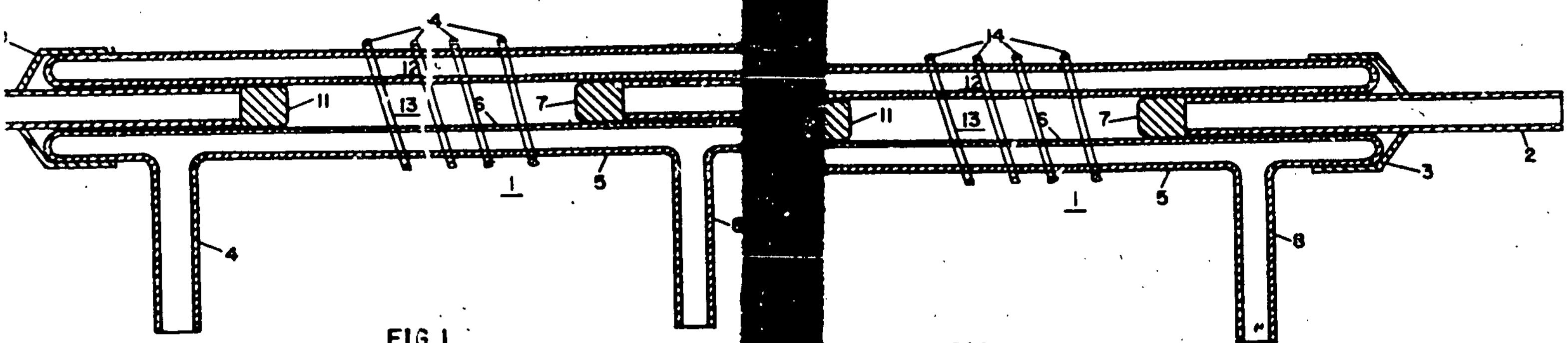

FIG. 1 FIG. 1

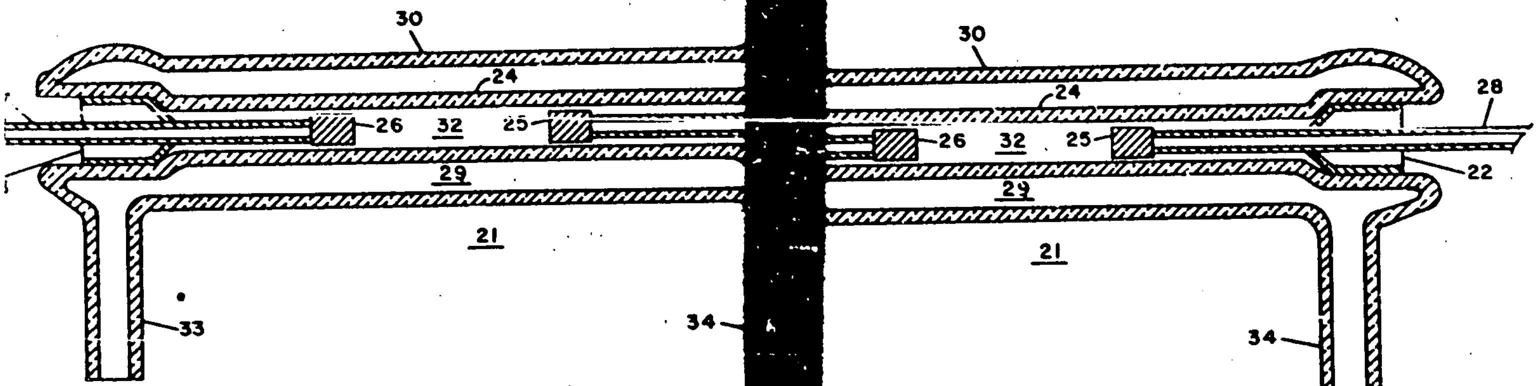

FIG. 2 FIG. 2

FIG.3

FIG.3

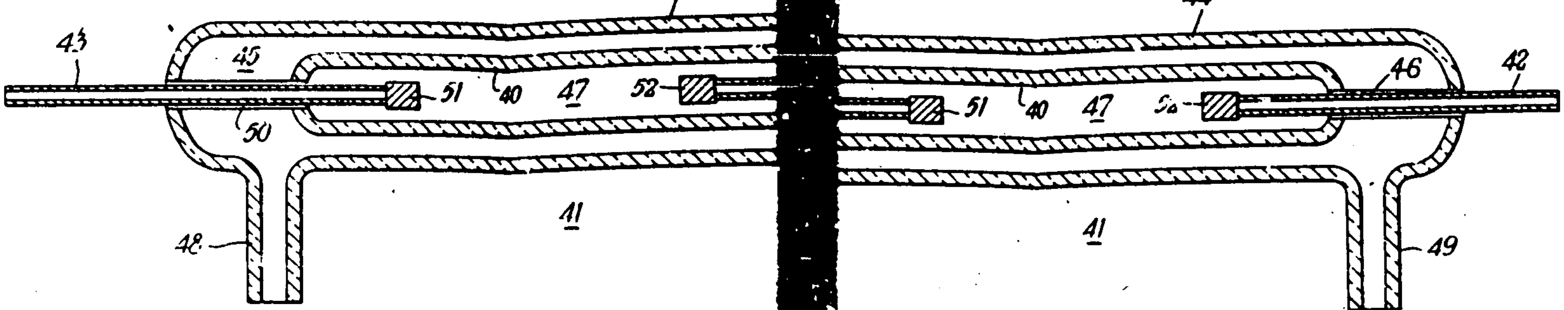

FIG.4

FIG.4